

## CLAIMS

1. A porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a mixture of a cementitious material and a bauxite refinery residue.
2. A porous particulate material as claimed in claim 1, wherein the volume of the pores is  
5 between 10% and 90% of the volume of the particulate material.
3. A porous particulate material as claimed in claim 1, wherein at least 10 % of the pores are open cell or interconnected pores.
4. A porous particulate material as claimed in claim 1, wherein the pores of the particulate material have a distributed pore size.
- 10 5. A porous particulate material as claimed in claim 1, wherein the pore size of the particulate material is within the range of 0.1 to 2000  $\mu\text{m}$ .
6. A porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a coherent mass of particles, each of which comprises a mixture of a cementitious material and a bauxite refinery residue.
- 15 7. A porous particulate material as claimed in claim 6, having a form selected from the group consisting of granules, pellets, briquettes, extrudites, gravel, cobbles, blocks, interlocking blocks and slabs.
8. Use of a reactive permeable barrier comprising a permeable mass of porous particulate materials according to claim 1 or claim 6, in the treatment of a fluid containing a  
20 contaminant, wherein the permeable mass of porous particulate materials is disposed within a flow path of the fluid containing the contaminant.
9. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form a porous particulate  
25 material according to claim 1 or claim 6.
10. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form a porous particulate material according to claim 1 or claim 6, the composition further comprising a pore generating  
30 agent capable of generating pores within the particulate material upon mixing the composition in an aqueous medium.
11. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form porous particulate  
35 material according to claim 1 or claim 6, the composition further comprising a pore generating

agent capable of generating pores within the particulate material upon mixing the composition in an aqueous medium, wherein the pore generating agent is selected from hydrogen peroxide, organic polymers and a foaming agent.

12. A composition for forming porous particulate material for treating a fluid containing a  
5 contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form porous particulate material according to claim 1 or claim 6, the composition further comprising a phosphatising agent.

13. A method for producing porous particulate material for treating a fluid containing a  
contaminant, the particulate material comprising a coherent mass of particles, the method  
10 comprising:

(a) mixing bauxite refinery residue and a cementitious binder in an aqueous medium to form a slurry; and

(b) curing the slurry at an elevated temperature and for a period of time sufficient to form the porous particulate material.

14. A method for producing a porous particulate material for treating a fluid containing a  
15 contaminant, the particulate material comprising a coherent mass of particles, the method comprising:

(a) mixing bauxite refinery residue and a cementitious binder in an aqueous medium to form a slurry; and

20 (b) curing the slurry in a mould to form a coherent mass of the porous particulate material wherein the mould is shaped to impart to the porous particulate material in a form selected from the group consisting of granules, pellets, briquettes, extrudites, gravel, cobbles, blocks, interlocking blocks and slabs.

15. A method for producing porous particulate material for treating a fluid containing a  
25 contaminant, the particulate material comprising a coherent mass of particles, the method comprising:

(a) mixing bauxite refinery residue and cementitious binder in aqueous media to form a slurry; and

30 (b) curing the slurry at an elevated temperature and for a period of time sufficient to form the porous particulate material,

wherein a phosphatising agent is added in step (a) and mixed with the residue and the binder to assist in stabilisation of the pore structures during curing.

16. A method as claimed in claim 13, 14 or 15, wherein the slurry comprises from about 1% to about 99% w/w of bauxite refinery residue and from about 1% to about 99% w/w of a  
35 cementitious binder.

17. A method as claimed in claim 13, 14 or 15, wherein the slurry further comprises an additive selected from the group consisting of sand, ground caustic steel slag residue, alkali metal hydroxides, alkali metal carbonates, alkaline earth metal hydroxides, alkaline earth metal carbonates, alkaline earth metal oxides, calcium hypochlorite, sodium alum, ferrous sulfate, ferric sulphate, ferric chloride, aluminium sulfate, gypsum, phosphates, phosphoric acid, hydrotalcite, zeolites, olivines, pyroxenes, barium chloride, silicic acid and salts thereof, meta silicic acid and salts thereof, an alunite group mineral, magadiite, a silica provider, a plasticiser, a polymeriser, a phosphatising agent, an air entraining agent and a combination of any two or more of the foregoing.

18. A method as claimed in claim 13, 14 or 15, wherein the bauxite refinery residue has a pH less than about 10.5.

19. A method as claimed in claim 13, 14 or 15, wherein the cementitious binder is capable of forming a tobermorite gel.

20. A method for treating a fluid containing a contaminant, the method comprising:

- providing a permeable mass of porous particulate materials according to claim 1 or claim 6; and
- passing the fluid containing the contaminant through the permeable mass of porous particulate materials.

21. A cementitious composition comprising partially neutralised red mud and cement, wherein the partially neutralised red mud has been pre-treated by contacting it with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent.

22. A cementitious composition as claimed in claim 21, wherein the cement is present in the composition in a concentration of from about 1 wt% to about 99 wt% and the partially neutralised red mud is present in the composition in a concentration of from about 99 wt% to about 1 wt%.

23. A cementitious composition as claimed in claim 21, further comprising from 0.2 wt % to 3 wt% of the cement of a super-plasticizer.

24. A cementitious composition as claimed in claim 21, further comprising a plasticiser selected from the group consisting of cellulose ethers, methyl-hydroxyethyl-cellulose (MHEC) and hydroxypropyl-methyl-cellulose (HPMC).

25. A process for the manufacture of a cementitious composition comprising

- (a) contacting red mud recovered from the Bayer Process with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent, so as to obtain a partially neutralised red mud; and

- (b) mixing the partially neutralised red mud with cement so as to obtain the cementitious composition.

26. A process for the manufacture of a cementitious composition as claimed in claim 25, wherein, in step (a), the pH of the red mud is reduced to a value of at most about 10.5 and at least  
5 about 8.2.

27. A process for the manufacture of a cementitious composition as claimed in claim 25, including a step (a1), after step (a) and before step (b), in which the partially neutralised red mud is dried to obtain a dry solid material.

28. A process for the manufacture of a cementitious composition as claimed in claim 25,  
10 including a step (a1), after step (a) and before step (b), in which the partially neutralised red mud is dried to obtain a dry solid material and a further step (a2), after step (a1) and before step (b), in which the dry solid material of step (a1) is comminuted so as to obtain a partially neutralised dry, comminuted red mud.

**AMENDED CLAIMS**

[received by the International Bureau on 27 April 2005 (27.04.05);  
original claims 1-28 replaced by amended claims 1-28 (4 pages)]

**CLAIMS**

1. A porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a mixture of a cementitious material and a partially neutralised red mud, wherein the partially neutralised red mud has been pre-treated by contacting it with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent.
2. A porous particulate material as claimed in claim 1, wherein the volume of the pores is between 10% and 90% of the volume of the particulate material.
3. A porous particulate material as claimed in claim 1, wherein at least 10 % of the pores are open cell or interconnected pores.
4. A porous particulate material as claimed in claim 1, wherein the pores of the particulate material have a distributed pore size.
5. A porous particulate material as claimed in claim 1, wherein the pore size of the particulate material is within the range of 0.1 to 2000  $\mu\text{m}$ .
6. A porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a coherent mass of particles, each of which comprises a mixture of a cementitious material and a partially neutralised red mud, wherein the partially neutralised red mud has been pre-treated by contacting it with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent.
7. A porous particulate material as claimed in claim 6, having a form selected from the group consisting of granules, pellets, briquettes, extrudites, gravel, cobbles, blocks, interlocking blocks and slabs.
8. Use of a reactive permeable barrier or a reaction/filter column comprising a permeable mass of porous particulate materials according to claim 1 or claim 6, in the treatment of a fluid containing a contaminant, wherein the permeable mass of porous particulate materials is disposed within a flow path of the fluid containing the contaminant.
9. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form a porous particulate material according to claim 1 or claim 6.
10. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form a porous particulate material according to claim 1 or claim 6, the composition further comprising a pore generating

agent capable of generating pores within the particulate material upon mixing the composition in an aqueous medium.

11. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form porous particulate material according to claim 1 or claim 6, the composition further comprising a pore generating agent capable of generating pores within the particulate material upon mixing the composition in an aqueous medium, wherein the pore generating agent is selected from hydrogen peroxide, organic polymers and a foaming agent.

12. A composition for forming porous particulate material for treating a fluid containing a contaminant, the composition comprising bauxite refinery residue and a cementitious binder, wherein the cementitious binder is present in a sufficient quantity to form porous particulate material according to claim 1 or claim 6, the composition further comprising a phosphorising agent.

13. A method for producing porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a coherent mass of particles, the method comprising:

(a) partially neutralising red mud by contacting it with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent;

(b) mixing the partially neutralised red mud with a cementitious binder in an aqueous medium to form a slurry; and

(c) curing the slurry for a period of time sufficient to form the porous particulate material.

14. A method for producing a porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a coherent mass of particles, the method comprising:

(a) partially neutralising red mud by contacting it with water having a total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent;

(b) mixing the partially neutralised red mud with a cementitious binder in an aqueous medium to form a slurry; and

(c) curing the slurry in a mould to form a coherent mass of the porous particulate material, wherein the mould is shaped to impart to the porous particulate material a form selected from the group consisting of granules, pellets, briquettes, extrudites, gravel, cobbles, blocks, interlocking blocks and slabs.

15. A method for producing porous particulate material for treating a fluid containing a contaminant, the particulate material comprising a coherent mass of particles, the method comprising:

(a) partially neutralised red mud by contacting it with water having a total hardness  
5 supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent;

(b) mixing the partially neutralised red mud with a cementitious binder in aqueous medium to form a slurry; and

(c) curing the slurry for a period of time sufficient to form the porous particulate  
10 material,

wherein a phosphorising agent is added in step (a) and mixed with the residue and the binder to assist in stabilisation of the pore structures during curing.

16. A method as claimed in claim 13, 14 or 15, wherein the slurry comprises from about 1% to about 99% w/w of bauxite refinery residue and from about 1% to about 99% w/w of a  
15 cementitious binder.

17. A method as claimed in claim 13, 14 or 15, wherein the slurry further comprises one or more additives selected from the group consisting of sand, ground caustic steel slag residue, alkali metal hydroxides, alkali metal carbonates, alkaline earth metal hydroxides, alkaline earth metal carbonates, alkaline earth metal oxides, calcium hypochlorite, sodium alum, ferrous sulfate, ferric  
20 sulphate, ferric chloride, aluminium sulfate, gypsum, phosphates, phosphoric acid, hydrotalcite, zeolites, olivines, pyroxenes, barium chloride, silicic acid and salts thereof, meta silicic acid and salts thereof, an alunite group mineral, magadiite, a silica provider, a plasticiser, a polymeriser, a phosphatising agent, and an air entraining agent.

18. A method as claimed in claim 13, 14 or 15, wherein the bauxite refinery residue has a  
25 pH less than about 10.5.

19. A method as claimed in claim 13, 14 or 15, wherein the cementitious binder is capable of forming a tobermorite gel.

20. A method for treating a fluid containing a contaminant, the method comprising:

- providing a permeable mass of porous particulate materials according to claim 1 or  
30 claim 6; and

- passing the fluid containing the contaminant through the permeable mass of porous particulate materials.

21. A cementitious composition comprising partially neutralised red mud and cement, wherein the partially neutralised red mud has been pre-treated by contacting it with water having a

total hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per litre calcium carbonate equivalent.

22. A cementitious composition as claimed in claim 21, wherein the cement is present in the composition in a concentration of from about 1 wt% to about 99 wt% and the partially  
5 neutralised red mud is present in the composition in a concentration of from about 99 wt% to about 1 wt%.

23. A cementitious composition as claimed in claim 21, further comprising from 0.2 wt % to 3 wt% of the cement of a super-plasticizer.

24. A cementitious composition as claimed in claim 21, further comprising a plasticiser  
10 selected from the group consisting of cellulose ethers, methyl-hydroxyethyl-cellulose (MHEC) and hydroxypropyl-methyl-cellulose (HPMC).

25. A process for the manufacture of a cementitious composition comprising  
- (a) contacting red mud recovered from the Bayer Process with water having a total  
hardness supplied by calcium, magnesium or a combination thereof, of at least 3.5 millimoles per  
15 litre calcium carbonate equivalent, so as to obtain a partially neutralised red mud; and  
- (b) mixing the partially neutralised red mud with cement so as to obtain the  
cementitious composition.

26. A process for the manufacture of a cementitious composition as claimed in claim 25,  
wherein, in step (a), the pH of the red mud is reduced to a value of at most about 10.5 and at least  
20 about 8.2.

27. A process for the manufacture of a cementitious composition as claimed in claim 25,  
including a step (a1), after step (a) and before step (b), in which the partially neutralised red mud is  
dried to obtain a dry solid material.

28. A process for the manufacture of a cementitious composition as claimed in claim 25,  
25 including a step (a1), after step (a) and before step (b), in which the partially neutralised red mud is  
dried to obtain a dry solid material and a further step (a2), after step (a1) and before step (b), in  
which the dry solid material of step (a1) is comminuted so as to obtain a partially neutralised dry,  
comminuted red mud.